

What is claimed is:

1. A gas spring, comprising:
  - an outer tube having a top and a bottom and being closed off at the bottom;
  - 5 a head plate connected to the top of said outer tube and defining a central opening;
  - an inner tube having a top and a bottom and mounted to extend downwardly from said head plate within said outer tube;
  - 10 a piston rod extending coaxially from within said inner tube, through the central opening in said head plate and outwardly of said head plate, said piston rod defining an inner trap and being mounted to reciprocate between a retracted, compressed position and an extended, rest position;
  - an inner piston having a top and a bottom and being disposed coaxially between said inner tube and said piston rod to reciprocate within the inner trap;
  - 15 elements connected with at least one of said inner and outer tubes to define an outer trap;
  - an outer piston having a top and a bottom and being disposed coaxially between said inner tube and said outer tube for vertical reciprocation within the outer trap;
  - wherein said outer tube, inner tube, outer piston, inner piston and piston rod 20 define a primary gas chamber;
  - wherein said outer tube, inner tube, outer piston and head plate define an outer oil chamber;
  - wherein said inner tube, inner piston, piston rod and head plate define an inner oil chamber;

wherein at least one of said head plate and said inner tube defines a valve passageway extending between the outer oil chamber and the inner oil chamber, the valve passageway including a first opening to the inner oil chamber and a second opening to the outer oil chamber;

5 a valve member disposed proximal the valve passageway and operable to variably control fluid flow between the inner oil chamber and the outer oil chamber;

wherein the inner trap includes said inner piston having an upper position closing off the valve passageway; and,

10 seals for preventing undesired fluid flow from the primary gas chamber, inner oil chamber and outer oil chamber.

2. The gas spring of claim 1 wherein said piston rod has a primary diameter portion and a reduced diameter portion and said inner piston is a toroidal-shaped ring that surrounds said piston rod at the reduced diameter portion.

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3. The gas spring of claim 2 wherein the inner trap is at the reduced diameter portion and defines the limits of movement of said inner piston.

20 4. The gas spring of claim 1 wherein the outer trap includes at least one stop member connected with at least one of said inner tube and said outer tube, and the outer trap defines the limits of movement of said outer piston.

5. The gas spring of claim 1 wherein the valve passageway includes a recess defined in the top of said inner tube.

6. The gas spring of claim 1 wherein the valve passageway includes a  
5 passageway defined in said head plate.

7. The gas spring of claim 1 wherein said valve member includes at least one check valve assembly that includes a check valve permitting fluid flow only from the outer oil chamber to the inner oil chamber.

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8. The gas spring of claim 1 wherein said valve member includes at least one flow control assembly juxtaposed proximal the valve passageway and being for modulating the rate of fluid flow from the inner oil chamber to the outer oil chamber.

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9. The gas spring of claim 1 wherein said valve member is a valve ring disposed between said inner tube and said outer tube, the valve ring including a check valve assembly permitting fluid flow only from the outer oil chamber to the inner oil chamber and a flow control assembly for modulating the rate of fluid flow from the inner oil chamber to the outer oil chamber.

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10. The gas spring of claim 9 wherein the flow control assembly defines a valve ring passageway extending between the valve passageway of said head plate and

the outer oil chamber, and includes a poppet disposed for vertical reciprocation in the valve ring passageway.

11. The gas spring of claim 10 wherein the poppet defines a restricted flow passageway and the valve ring defines at least one bypass passageway extending from the restricted flow passageway to the outer oil chamber, and wherein the poppet has an upper, closed position blocking fluid flow between the valve ring passageway and the outer oil chamber and a down, open position permitting fluid flow between the inner and outer oil chambers through the valve passageway, valve ring passageway and bypass passageway.

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12. The gas spring of claim 1 further including a manifold having at least one port sized and configured to connect with said first tube whereby said manifold is in communication with the primary gas chamber and wherein the bottom of said outer tube is closed by being connected to said manifold.

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13. A soft-start, soft-return gas spring, comprising:  
an outer tube having a top and a bottom that is closed off;  
a head plate connected to the top of said outer tube and defining a central opening;  
an inner tube mounted to extend downwardly from said head plate;  
a piston rod extending through the central opening, having an inboard end in said inner tube, having an outboard end extending upwardly of said head plate, and operating to reciprocate between an extended, rest position and a retracted, compressed position,

movement toward the retracted, compressed position being a downstroke and movement toward the extended, rest position being an upstroke;

an inner piston disposed between said piston rod and said inner tube;

an outer piston disposed between said inner tube and said outer tube;

5 a primary gas chamber defined by said outer tube, inner tube, outer piston, inner piston and piston rod;

an outer oil chamber defined by said outer tube; inner tube; outer piston and head plate;

an inner oil chamber defined by said inner tube; inner piston, piston rod and head plate;

10 valve passageway means for providing communication between said inner oil chamber and said outer oil chamber;

seals for preventing undesired fluid flow from said primary gas chamber, inner oil chamber and outer oil chamber;

15 first valve means for blocking fluid flow through the valve passageway when said piston rod is near the extended, rest position; and,

second valve means for regulating fluid flow in the valve passageway, said valve means permitting substantially free flow from said outer oil chamber to said inner oil chamber and regulating flow from said inner oil chamber to said outer oil chamber to

20 between at least a first and a second flow rate.

14. The gas spring of claim 13 wherein said first valve means includes said piston rod defining an inner trap that defines the vertical limits of movement of said inner piston relative to said piston rod.

5 15. The gas spring of claim 14 wherein said inner trap includes said inner piston having an upper position closing off the valve passageway.

16. The gas spring of claim 15 wherein the inner trap includes said piston rod having a reduced diameter section around which said inner piston is disposed.

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17. The gas spring of claim 13 wherein said valve passageway means includes at least one of said head plate and said inner tube defining a valve passageway extending between the outer oil chamber and the inner oil chamber, the valve passageway including a first opening to the inner oil chamber and a second opening to the outer oil chamber.

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18. The gas spring of claim 13 wherein said valve passageway means includes said head plate defining a valve passageway extending between the outer oil chamber and the inner oil chamber, the valve passageway including a first opening to the inner oil chamber and a second opening to the outer oil chamber.

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19. The gas spring of claim 18 wherein said inner tube has a top and said valve passageway means includes a recess defined in the top of said inner tube, the recess being in communication with the valve passageway and said inner oil chamber.

20. The gas spring of claim 19 wherein said first valve means includes said piston rod defining an inner trap that defines the vertical limits of movement of said inner piston relative to said piston rod and that includes said inner piston having an upper 5 position closing off the first opening and the recess.

21. The gas spring of claim 13 wherein said first valve means regulates fluid flow in said passageway means as a function of the position of said piston rod.

10 22. The gas spring of claim 13 wherein said second valve means regulates fluid flow in said passageway means as a function of the direction of travel of said piston rod.

15 23. The gas spring of claim 13 wherein said second valve means includes at least one check valve assembly that includes a check valve permitting substantially free fluid flow from the outer oil chamber to the inner oil chamber.

20 24. The gas spring of claim 13 wherein said valve passageway means includes at least one of said head plate and said inner tube defining a valve passageway extending between the outer oil chamber and the inner oil chamber, the valve passageway including a first opening to the inner oil chamber and a second opening to the outer oil chamber, and wherein said second valve means includes at least one flow control assembly

juxtaposed proximal the valve passageway and being for regulating the rate of fluid flow from the inner oil chamber to the outer oil chamber.

25. The gas spring of claim 13 wherein said valve passageway means includes

5 at least one of said head plate and said inner tube defining a valve passageway extending between the outer oil chamber and the inner oil chamber, the valve passageway including a first opening to the inner oil chamber and a second opening to the outer oil chamber, and wherein said valve member is a valve ring disposed between said inner tube and said outer tube, the valve ring including a check valve assembly permitting fluid flow only

10 from the outer oil chamber to the inner oil chamber and a flow control assembly for regulating the rate of fluid flow from the inner oil chamber to the outer oil chamber.

26. The gas spring of claim 25 wherein the flow control assembly defines a valve ring passageway extending between the valve passageway of said head plate and the outer oil chamber, and includes a poppet disposed for vertical reciprocation in the valve ring passageway.

27. The gas spring of claim 26 wherein the poppet defines a restricted flow passageway and the valve ring defines at least one bypass passageway extending from the 20 restricted flow passageway to the outer oil chamber, and wherein the poppet has an upper, closed position blocking fluid flow between the valve ring passageway and the outer oil chamber and a down, open position permitting fluid flow between the inner and outer oil chambers through the valve passageway, valve ring passageway and bypass passageway.

28. The gas spring of claim 13 further including a manifold having at least one port sized and configured to connect with said first tube whereby said manifold is in communication with the primary gas chamber and wherein the bottom of said outer tube  
5 is closed off by being connected to said manifold.